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# JOINT SURVEILLANCE SYSTEM DISTRIBUTED TRACKER


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13. ABSTRACT (Maximum 200 words)
The Joint Surveillance System Distributed Tracker (JDT) was designed by Hughes Aircraft Company for use in a laboratory environment in conjunction with Command and Control experiments in support of the air defense initiative. The tracker provides a live air picture for integration with the Air Defense Initiative Simulation for Command and Control (ADISC2). It was designed to accept radar inputs from up to ten (10) Joint Surveillance System (JSS) radars. The raw radar data is preprocessed and each radar report is "tagged" with a radar site ID. The data is then broadcast over an Ethernet to the JDT which resides on a SUN 4-260 workstation. A track file is then automatically established for each of the ten (10) radar sites using an N hit out of M scan approach. A master track store is then established through the correlation of the individual track files providing a single correlated air picture for the ten (10) radar sites.

Automatic track initiation is performed over multiple radar scans. A one-plot track is formed initially. If on the next scan, a plot is correlated with a one-plot track, that track is upgraded to a tentative track. Should subsequent scans correlate with the tentative track, the track is upgraded to system track status and is then eligible for display. Tracks can also be manually initiated through mouse driven menu interaction.
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The JDT software is structured as four (4) processes (radar inputs, tracking, track-to-track correlation, and displays) and two (2) object libraries (interprocess communication, and track telling). This separation of functional modules allows any process to reside remotely and communicate with other workstations via the interprocess communications package. This allows distribution of functionality among several workstations on the network.

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# DISTRIBUTED TRACKER (JDT)

## 1. SYSTEM OVERVIEW

1.1 The purpose of the JDT system is to accept radar plot data from up to ten Joint Surveillance System (JSS) radars and perform the tracking function to create an integrated air picture display for the area of coverage of those radars. The system will automatically generate tracks based on the radar data using an (N) hit out of (M) scan approach. The JDT will also be capable of communicating track data out of the system and to other processes running concurrently in the system. The system has a track correlation process that can accept track data from a maximum of ten tracking processes running concurrently in the system, resolve track data resulting from reports from different radars on the same target, and produce a master track file. Map overlays will be used to display information and the Man-Machine Interface (MMI) will allow for keyboard entries and mouse selections. Track control keys allow for manual track initiation, entry of track tell status, and selection of non-automatic track initiation (NAI) zones. In addition, an interface to the ADISC2 Testbed is provided.

1.2 The JDT system is designed to operate in one or more SUN4 workstations under the UNIX operating system. The software is organized into six CSCIs. These CSCIs are composed of four processes: (1) Tracking, (2) Track to Track Correlation, (3) Display, and (4) Radar Inputs; and two object libraries: (1) Interprocess Communication (IPC) and (2)Telling. The JDT processes communicate with one another via the IPC which allows them to operate within a single workstation as well as to be distributed into multiple workstations. The development work was performed using a single workstation; however, when the system was installed at RADC, the display process was separated to operate in a second workstation to allow a larger radar load to be handled by the tracking process. Figure 1.2 illustrates the interrelationship between the JDT processes. The IPC has been left out to simplify the figure. Basically the IPC would be shown as the interface between each process in a more detailed drawing. A major feature of the JDT design is the capability to operate software processes in multiple workstations. Note the duplication of the Tracking process to provide one process for each radar feeding the system. This supports handling each radar with a separate workstation, all radars with a single workstation, or any combination in between. This gives extreme configuration flexibility to adjust to various load conditions.

# JDT SOFTWARE FUNCTIONS

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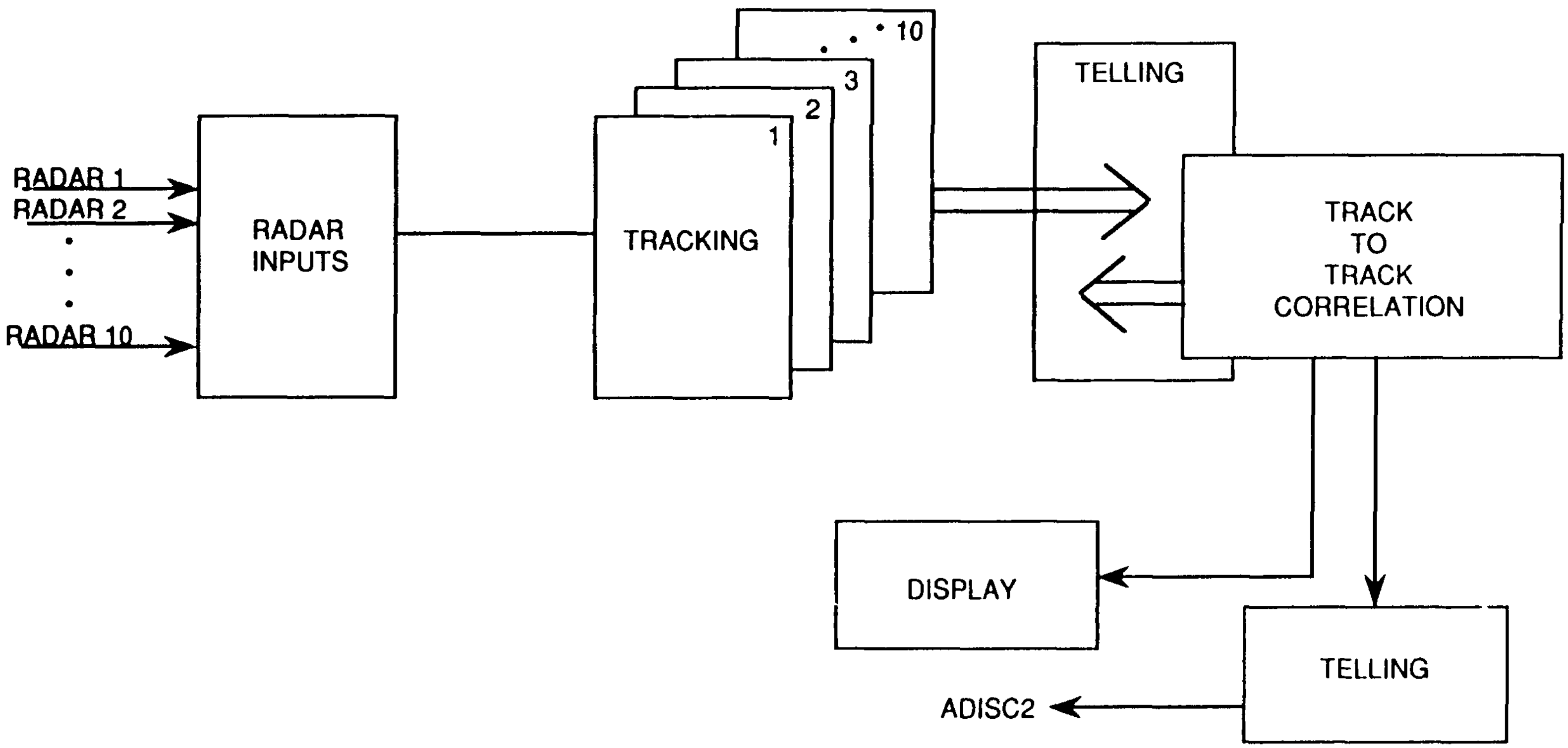


FIGURE 1.2

## 2. JDT SOFTWARE FUNCTIONAL DESCRIPTION

2.1 JDT Interprocess Communication (IPC) is the routing process within the JDT system. It receives all messages and routes them to their proper destination. It also provides two modules that other processes may use to read and write messages to and from the IPC. The IPC is the key to providing the configuration flexibility required for the JDT system. The IPC routes process to process messages based on data stored in the configuration and startup files. This allows the processes to communicate independent of the allocation of processes among the available workstations.

2.2 The Telling library provides for the packing and unpacking of the Track Data Message and the Change Track Number Message. Telling is a library of routines used to accomplish the processing of messages. The Telling library provides a common message format for transmission between the Tracker and Correlator or ADISC2. This common message format is the JSS Track Data Message format.

2.3 The Tracking process is capable of generating maintaining, and processing tracks which represent the position, velocity, and status of aircraft. A system track will be generated by a specific initiation process (automatic or manual) and continues to exist until one frame (equivalent to scan time of the radar) after completion of a specific drop process. System track data is eligible for display. The system track capacity for each tracking process is 300 tracks. Up to ten tracking processes can be active in the JDT system at a time (one for each radar interfaced with JDT).

The tracking function generates the track number, position, velocity, and status of aircraft based upon automatic processing of Surveillance Radar (SR) and Secondary Surveillance Radar (SSR) data received from radar sites. This information is known collectively as track information. Tracking is performed through the following processes: manual track initiation; automatic initiation; and automatic correlation, smoothing, and prediction.

The manual track initiation is primarily an operator function. It is performed by the operator specifying the position and velocity of the aircraft. The tracking process then initiates the track based on this data.

The automatic initiation process is performed over several radar scans. It is initiated when a radar return is received which fails to correlate with any system or non-system track. The first step is to form a one-plot track (a non-system track) at the location of the radar return. The second step of the process occurs approximately one scan later if a radar return correlates with the existing one-plot track. It is then promoted to a tentative track (also a non-system track). The tentative track will eventually be promoted to a system track if it continues to correlate with radar returns on successive scans of the radar. The maximum number of one-plot and tentative tracks is 500.

Automatic correlation, smoothing, and prediction is the process of comparing radar return data with existing track data, deciding if it matches the track (correlation), and updating the track based on the radar return data and the history of the track (smoothing and prediction). In an ideal situation and where a track is not maneuvering, one would expect that the best update for a track would be to use the radar return data once correlation is accomplished. However, the real environment involves getting noise returns, as well as real returns, and missing some real returns so there is never a certainty that a correlation of a radar return with a track really means they represent the same aircraft. Smoothing is a function which addresses this uncertainty. Basically smoothing results in partially believing the radar return and partially believing the projected track position and velocity based on track history. The track is updated based on a compromise of these two sets of data by a software algorithm.

Maneuvering targets present a special situation. Since the radar return data will not match the tracks expected data based on history when the aircraft is maneuvering, there is an uncertainty in the correlation. It may represent correlation of a maneuvering aircraft or it may simply be the result of correlation with a noise return. The JDT system handles this situation by creating a bifurcating track (another non-system track). The result is that the operator sees the system track at the workstation continue approximately as if it is not maneuvering. Meanwhile, Tracking is following the possible maneuver with the bifurcated track which is not displayed. Over a predetermined set of radar scans, it is determined which path (the non-maneuvering vs the maneuvering) appears to represent the actual aircraft's behavior. The bifurcation is then resolved in favor of the track with the best correlation history. If this results in believing that the track is maneuvering, the system track will appear to jump as its position is corrected to be placed on the maneuver path.

2.4 The purpose of the JDT Track to Track Correlation process is to automatically determine if new track data received from one of the Tracking processes correlates with track data already established in the Master track file. The process considers the following track attributes in making this decision:

- Track Number
- SIF Data
- Track Position and Velocity

The correlation status of a track may go through several provisional states before a firm decision is made, but the processing results in one of two possible decisions:

- The track is a single track ( the track is reported by only one tracker)
- The track is one of a pair of tracks (the track is being reported by two or more trackers)

If it is determined a new pair has been formed, then a change track number message is sent to the tracker which sent the new track data. This process assures that all trackers use the same track number for an individual aircraft.

2.5 The Display process provides the man-machine interface (MMI) to the operator. It provides for display of dynamic situation data, tracks and plots as well as the MMI menus, keyboard control, and mouse control. The display process interfaces with the SUN-resident commercial package FIGARO to provide this functionality. The MMI and display features of JDT are described fully in Chapter 5 and Chapter 6 of Development Program Manual for this contract.

2.6 The purpose of the Radar Inputs process is to receive radar data from the Radar Data Interface Unit (RDIU) and from the ADISC2 Testbed. This radar data is then buffered, formatted, and transmitted to the proper tracker once per second.

## 3.0 FINAL TEST REPORT

The formal JDT system testing was accomplished by running five Tracker Acceptance Tests (TATS). These tests are listed together with synopsis in Table 3.0. The tests were run at Hughes GSG in Fullerton as part of the JDT system checkout, and all detected problems were corrected. The tests were then run formally at RADC and were witnessed by RADC personnel as part of the formal system selloff.

3.1 Testing at GSG - The original test plan for the JDT system was to run the acceptance tests with both simulated data and with recorded live data to thoroughly test the system prior to shipping to RADC. The recorded live data was obtained from RADC and was input to the SUN workstation via the RADC developed RDIU. During the contract execution , the RDIU had a failure which RADC was unable to repair at the contractor's facility. This required performing all the checkout and testing of the JDT system at GSG with simulated data. This limitation resulted in comprehensive functional testing but under limited load conditions. Consequently, the first time the system was tested under realistic load conditions was after installation at RADC and with live radar data.

3.2 Testing at RADC - Testing began at RADC in early October 1989. Initial installation, checkout, and testing with simulated data went well with JDT passing all these tests as it had in Fullerton. However, testing under full load conditions revealed, as expected, some system limitations. First the system could not handle a full load from six radars. This was due partially because the commercial software used to create the JDT displays was a heavy CPU user under this load condition. This problem was lessened by moving the display process to a second SUN workstation. Analysis of the remaining problems revealed that special care had to be exercised when using the UNIX socket feature under heavy load conditions. This feature was used to pass data between processes. In particular, the use of UNIX sockets for passing plot data from radar inputs to tracking had to be redesigned and implemented to handle the live radar load conditions experienced at RADC.

One other major problem became apparent while running under full load for prolonged periods of time. Eventually the number of tracks processed by the system began to drop, gradually falling far below the number of tracks the system was designed to handle. This problem, which had a variety of symptoms, also had a variety of causes. Basically they were all related to the scheme for re-using track numbers and track slots, which are returned for reuse by a tracker after a track is dropped. This led to a complicated set of logic which controls re-establishing these track numbers and storage locations for use by new tracks. After extensive analysis and testing and a great deal of support from RADC personnel, this logic was re-implemented so it now supports the load environment required for the JDT system. The final testing was completed in late January 1990.

TABLE 3.0

TAT LIST AND SYNOPSIS

| TEST | TITLE | SYNOPSIS |
|---|---|---|
| TAT01 | Radar Inputs | Demonstrate real time acceptance of data messages from 10 JSS radars or the ADI Simulator (if available). |
| TAT02 | Automatic Track Generation | Demonstrate automatic track generation algorithms. Maintain tracks using an (n) hit out of (m) scan approach for all potential tracks within reporting range of radars. |
| TAT03 | Track Presentation | Demonstrate presentation of track data and individual radar reports using JSS symbology. Coverage of all ten radars will be shown. |
| TAT04 | Track Tell | Demonstrate capability to tell tracks to a concurrent internal process or to the ADI Simulator (if available). Three modes of operation will be demonstrated: tell all tracks; tell selected tracks; and stop track tell. |
| TAT05 | Track Correlation | Demonstrate acceptance of track tell input from a minimum of ten trackers and production of a master track file. |